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Research into Properties of Spot Welded Steel Sheets

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ABSTRACT

The contribution deals with parameter optimalization of resistance spot welding for hot-dip zinc coated steel sheets. The mechanical properties and metallographic observation of welded joints on galvanized steel sheets were performed. Uncoated sheets from the same material were used for comparison of particular properties. The results showed that welding parameter optimalization is very important for welding of galvanized steel sheets.

KEYWORDS: *resistance spot welding, optimization, evaluation of properties*

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I. INRODUCTION

In recent years we have seen rapid development of the automobile industry, in which an important place belongs to the resistance or spot welding, used mainly in the manufacture of passenger car bodies. It is therefore not surprising that the requirements of the car industry as to the use of galvanized sheets for car bodies have also increased [1-2]. Basic requirement for welding is the lowest possible damage of the protective coating on the surface of sheets. Mechanical values of the joint must be the same or be very close to the mechanical values of the base material [3]. Hot-dip galvanized steel sheets must be welded quickly so that zinc does not evaporate. Therefore higher intensity is used, and increased is also the pressing force (recommended welding parameters are higher by about 20%) and the welding current [4-5]. In this contribution the possibilities of spot welding of hot-dip zinc coated steel sheets is observed. The special attention is paid to the optimization of welding parameters, with subsequent evaluation of mechanical and metallographic properties of spot welds.

II. Methodology of experiments

For the experiments, steel sheets with the thickness of 0.8 mm with the grade of DC04 were used. The steel sheets were hot-dip zinc galvanized on both sides. Average thickness of the zinc coating was 34 micrometers. Thickness of coating was measured by a thickness gauge DIGI – DERM 745, made by MITUTOYO.

The properties of resistance spot welds of hot-dip galvanized steels were compared with resistance spot welds of uncoated sheets of the same thickness 0.8 mm and of the same grade DC04. The basic mechanical properties and chemical composition are shown in Tab. I. and Tab II. Cutting plan for the preparation of samples is shown in Fig. 1.

TABLE I. BASIC MECHANICAL PROPERTIES OF JOINED MATERIALS

Material (thickness)	R_e [MPa]	R_m [MPa]	A_{80} [%]
DC04 (0.8 mm)	210	325	40

TABLE II. CHEMICAL COMPOSITION OF JOINED MATERIALS IN WT [%]

Material (thickness)	C	Mn	P	S
DC04 (0.8 mm)	0.08	0.40	0.030	0.030

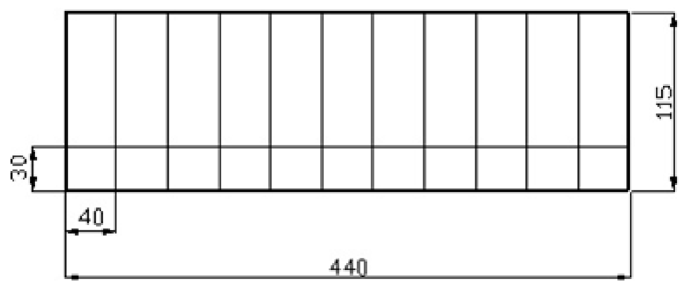


Fig. 1. Dimensions of sheet strips

Dimensions of samples were chosen according to the STN 051122 standard. Before welding the strips were cleaned with technical gasoline. For welding a spot welding machine BPK 20 was used. The CuCr electrodes (A2/1) according to the ON 42 3039.71 with a diameter of working area d_e = 5 mm were used in experiments. The welding parameters were selected according to the recommendations given in the

British Standard (BS 1140). We therefore tried welding at the lowest possible pressing force Fz = 3,2 kN.

For uncoated sheets, the following parameters of spot welding were used:
- pressing force Fz = 3,2 kN,
- welding time T = 3 and 5 periods,
- welding current I = 5,4; 6,0; 6,6; 7,2 kA at both periods.

For hot-dip zinc coated sheets following parameters of spot welding were used:
- pressing force Fz = 3,2 kN,
- welding time T = 4 and 6 periods,
- welding current I =7,2; 7,6; 8,0; 8,3; 8,6; 8,9 kA at both periods.

Overlap of welded strips was 30 mm (Fig. 2). At each value of welding current four welds were made, of which one was used for metallographic analysis, using a Neophot 2 microscope. After welding 40 mm wide samples were cut out of the strips, and these samples were used for the evaluation of mechanical properties of spot welds according to the STN 05 1122 standard. In this test the maximum strength of spot welds is determined by measuring the force needed to break the sample.

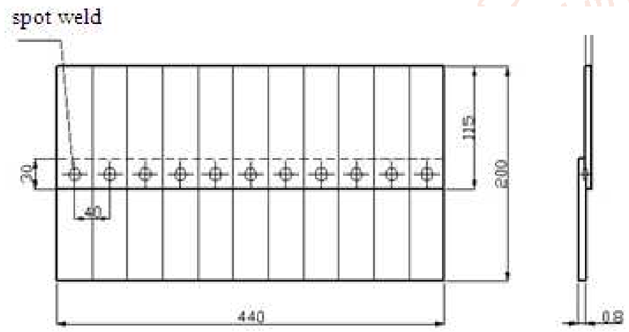


Fig. 2. The dimension of samples for welding

The tensile test was carried out on the metal strength testing machine TIRAtest 2300 produced by VEB TIW Rauenstein, with the loading speed of 8 mm/min.

III. results and discussion

Spot welds of uncoated sheets showed high values of load-bearing capacity for both periods of welding and for all values of welding current. The load-bearing capacity of the welds increased almost linearly with the increasing value of the welding current at both periods (Fig. 3 and 4).

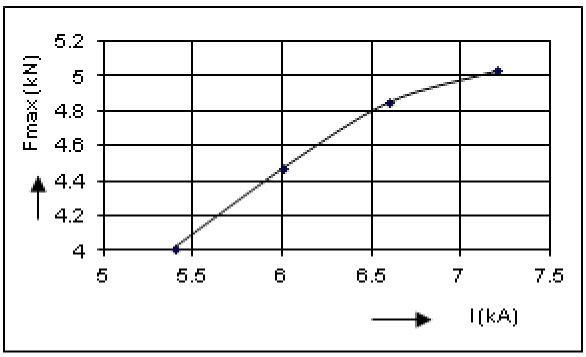
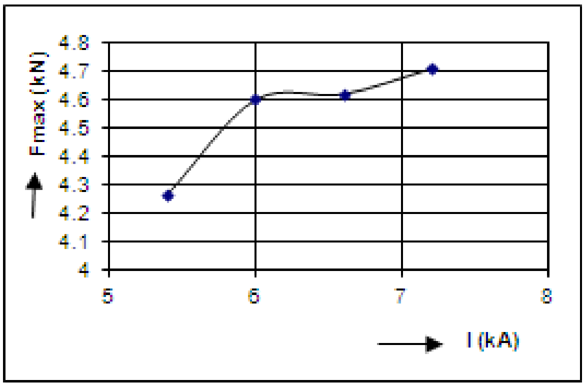


Fig. 3. Dependence of the load-bearing capacity Fmax on the welding current I for uncoated steel sheets; T = 3 periods

Fig. 4. Dependence of the load-bearing capacity Fmax on the welding current I for uncoated steel sheets; T = 5 periods



Spot welds of hot-dip galvanized steel sheets generally showed lower values of load-bearing capacity than those of uncoated sheets. It is seen in Fig. 5 and 6 that the values of load-bearing capacity Fmax show an apparent maximum at both periods. Curves for lower welding periods show maximum in a relatively narrow range. For higher periods the increase of Fmax values is less apparent. However, at lower welding currents and for both periods of welding these sheets showed also cold welded joints with low value of Fmax. Increase of the welding period for hot-dip zinc coated sheets did not result in improved properties, since the load-bearing capacity has decreased.

Fig. 5. Dependence of the load-bearing capacity Fmax on the welding current I for hot-dip galvanized steel sheets; T = 4 periods

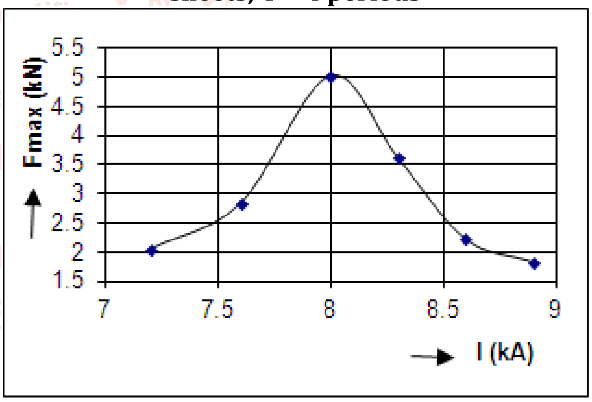
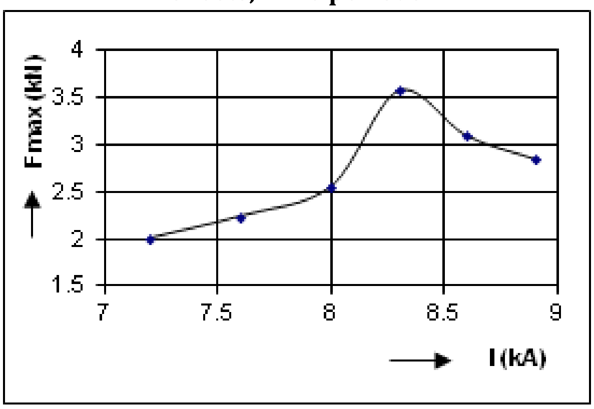


Fig. 6. Dependence of the load-bearing capacity Fmax on the welding current I for hot-dip galvanized steel sheets; T = 6 periods



Metallographic observation of welded joints of black sheets has shown the presence of only fusion welded joints without larger internal defect. Highest load-bearing capacity in hot-dip galvanized sheets was shown by joints representing certain boundary between diffusion and fusion joints, and this was caused by a relatively large adhesion area.

Fig.7 shows a typical example of the weld lens of a fusion joint, with dendritic structure on the whole cross-section of the weld.

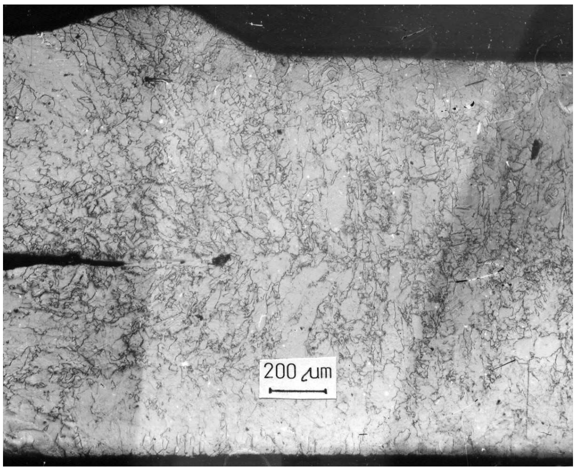


Fig. 7. Cold welded joint in the hot-dip galvanized steel sheet

At lower values of the welding current cold welded joint were produced at both periods (Fig. 8), while at high values of the welding current the load-bearing capacity of welded joints was lowered due to a number of cracks which were formed in the heat affected zone (Fig. 9).

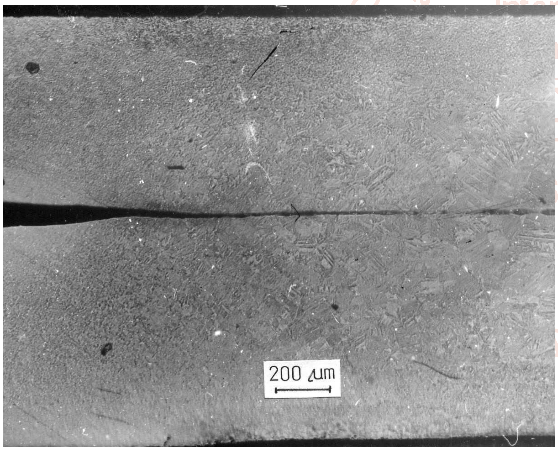


Fig. 8. Cold welded joint in the hot-dip galvanized steel sheet

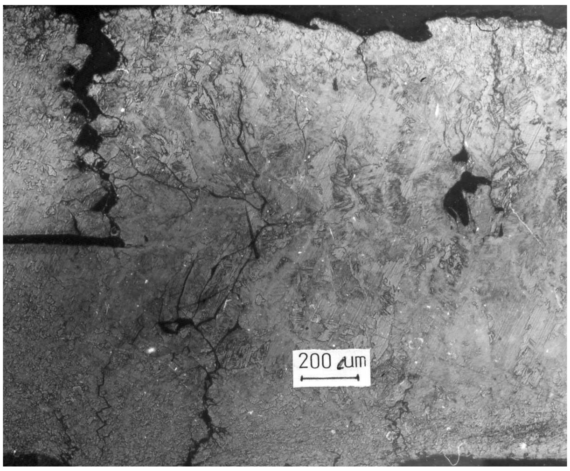


Fig. 9. Cracks in the heat affected zone in the hot-dip galvanized steel sheets

Conclusion

The paper was devoted to the optimization of the spot welding parameters for hot-dip zinc coated steel sheets. Properties of spot welds of these sheets were compared with those of black sheets of the same grade.

On the basis of obtained results we can make following conclusions:

- considering the load-bearing capacity of joints, for black sheets the welding parameters within practically whole investigated range may be used, with only fusion joints formed in welds,
- welding of hot-dip galvanized sheets produced both cold and fusion welded joints, the best properties were observed in fusion welded joints, whose load-bearing capacity showed an apparent maximum in dependence on the welding current,
- metallographic observation of welded joints in the hot-dip galvanized sheets confirmed the importance of a proper choice of welding parameters, since at low welding currents cold joints were produced and at high welding currents some defects appeared in welds, such as cracks in the heat affected zone and damaged surface of welded joints, which negatively influenced their strength,
- optimization of welding parameters for the spot welding of hot-dip galvanized sheets is an important result, since maximum values of the weld strength are obtained only in a relatively narrow range of welding current values.

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